Musculoskeletal injuries in British Army recruits: a prospective study of incidence in different Infantry regiments

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Abstract

Background: Musculoskeletal injuries and the subsequent attrition incurred during basic military training are a significant socioeconomic burden across many Defence forces. In order to plan an injury prevention strategy, the purpose of this study was to quantify the regiment specific musculoskeletal injury patterns and training outcomes. Methods: This was a prospective observational study of the Parachute (n = 734), Guards (n = 1044), Line (n = 3472) and Gurkha (n = 458) regiments of the British Army recruits during a 26 week basic military training programme over a two year period . The participant demographic characteristics were; age 18.9 years (SD ± 2.3), height 176.5 cm (SD ±7.80, mass 69 kg (SD ± 9.7) and body mass index 22.14 kg/m2 (SD ± 2.5). Results: The incidence of injuries (86, 46, 48 and 10%) were significantly different ($p < 0.001$) as were the first time pass out rates ($p = 0.02$) of 38, 51, 56 and 98% for Parachute, Guards, Line and Gurkha, respectively. Overuse injuries were more frequently reported than both acute and recurrent injuries in all Regiments ($X2 = 688.01$, $p< 0.01$). Conclusions: The disparity in injury incidence and training outcome between Infantry Regiments, suggests that the demands of training be taken into account when devising injury prevention strategies.

Introduction

Musculoskeletal injuries (MSKI) and attrition constitute a major socioeconomic burden to both military and civilian populations globally (1-10). The Infantry Training Centre (ITC) Catterick (UK) is the location for all basic Combat Infantryman's Course (CIC) within the British Army (2). The role of the centre is to deliver trained motivated personnel to the Field Army with dismounted close combat and leadership skills in order to meet the requirements of the Infantry and Defence [SCHINF Mission statement ITC Catterick, Battalion Directive 2015-16]. The completion of CIC training is mandatory for all infantry soldiers (10).

Training is administered through two Battalions and delivered across four separate Infantry regiments, Line, Parachute, Guards and Gurkha (2, 10). The course lasts for a minimum of twenty-six weeks. The training content is a blend of generic military training (1-13 weeks) followed by Regiment specific soldiering skills (10), representing combined Phase 1 and 2 training. The CIC Line Regiment focus on standardised line infantry tactical training, the CIC Gurads Regiment has an increased focus on footdrill, whilst the Parachute Regiment incorporates build up and completion of the arduous “P Company” parachute selection course. Gurkha training is the longest, due to incorporation of three blocks of targeted education. These consist of language and culture courses along with specific tactical closed combat and martial arts training. Ultimately all versions of the CIC course are designed to transform civilian young men into a class three infantry soldier prepared for transfer to the wider Army (2, 10). The planning, resourcing and administrative coordination across the ITC is conducted by the co-located Support Battalion.

Occupationally appropriate levels of physical fitness are requisite (1,8-9). Entry standards for the infantry are the most stringent of the British Army, demanding high levels of muscular strength, endurance and cardiovascular fitness (10-11). The arduous training regularly requires daily energy expenditures of over 5000 kilocalories (12). Training load and intensity varies between regiments with the most demanding physical activity in the Parachute Regiment (12).

Recruits experience a high level of physical and mental stress due to the multi-factorial components of military training (9-13) and the challenge of adapting the significant environmental changes as they transition from a civilian lifestyle. Moderate, controlled exercise has been shown to have a protective effect on tissue health and injury incidence (1). However, heavy volume and intense repeated exercise combined with sleep restriction and insufficient recovery has depressive effects on the immune function, which in turn, may contribute to musculoskeletal injury (1,8,15-16).

The incidence of MSKI in military training varies widely between studies. For example, reported incidences range from 20% in British Naval Officers (17), 47% in US Army (3-4), 59.7% in US Naval recruits (18) whilst 48.7% was reported in the British Army (2). The impact on military service is considerable. Notably, among the medical discharged (MD), 81% of recruits are MD due to lower limb and 13% for back and neck MSKI in British recruit (9,11). It is generally accepted that large and rapid increases in physical activity in military training with the associated psychological challenges can lead to MSKI (1-2,6-7,13-15). Military recruits are known to be at a higher risk of injury compared to trained soldiers (19). The lack of appropriate conditioning and preparation for increasing the intensity of training may be considered as a fault which in turn may contribute to greater incidence of potentially avoidable injury (1,8,16).

Musculoskeletal injury prevention programmes have for a long time, been of interest to military organizations globally (1,4,9-11). Based on initial clinical injury demographics there is an observational difference in terms of injury pattern and training outcome between the different training regiment at ITC. However, regimental specific injury patterns have not been reported (2,14). The first step is to establish any injury problem by comparing between the training regiments (20-21). Baseline data are a pre-requisite for identifying injury trends (9, 21) and introducing prevention strategies (20). Although incidence of injury during military training varies globally (1-2,7-8,15,17-18), the lower MSKI rate (20%) referred to above could attributed to natural attrition rates, however the higher injury incidence (59.7%) suggests a need for further investigation (20,22). However, there is a paucity of comparative studies describing injury presentation between co-located training regiments (2,10).

Army budgets are determined by policy makers who require evidence to underpin strategic decision making. Accurate statistics will contribute heavily to the rationale for introducing specific initiatives or change in training delivery. It is recognized that dedicated accountable initiatives are required to address the reduction of training injuries, loss of training days and/or premature discharge from service (1-2,11,20). Therefore, the aim of this study was to quantify regimental specific MSKI incidence, the injury types sub-classification and training outcomes.

Methods

This study had a prospective observational design. Data were collected from new recruit intakes over 26 weeks of training between 2006 and 2008 at the Infantry Training Centre (Catterick, UK). Recruits were provided with a brief of the study during the initial medical assessment before being invited to participate. Each recruit underwent measurement of Height and weight in the initial medical assessment. Height was measured in centimeters (cms) using Invicta, UK and weight was measured in kilograms (Kg) using Seca scales, Germany. Body mass index (BMI) was calculated using the set formula. The participants of this study were all male with mean age 18.9 years (SD ± 2.3), height 176.5 cm (SD ± 7.8), mass 69 kg (SD ± 9.7), body mass index 22.14 kg/m^2 (SD ± 2.5) and from four regiments with a total 6608 recruits. All participants had passed the initial medical assessment. The distribution of recruits between the four training regiments was as: Line (69.7%), Guards (15.8%), Parachute (11.1%) and Gurkha (6.9%). At the time of the research, these regiments trained for 26, 28, 28 and 39 weeks, respectively. However, injury data beyond 26 weeks were excluded in order to calculate a consistent injury rate among regiments. All participants consented prior to taking part in the study. Ethical approval was obtained from the Teesside University School of Social Sciences and Law Research Ethics Committee.

An overview of the CIC content has been presented previously (2, 10). The physical training component is delivered by a team of All Arms Physical Training Instructors (AAPTI) under the management and supervision of the Royal Army Physical Training Corps (RAPTC). The physical

training and development programme delivered across all training Regiments has been generic in format (Table 1). Any Unit specific variations to the intensity and volume have been applied in an ad-hoc manner. Infantry training programme is standardized and has been validated for regimental task specific requirements by the Army Recruiting and Training Division (ARTD).The volume of training load is highest for the Parachute and least for the Line, Regiment (10,12). The physical training programme is designed to improve aerobic power, muscle endurance and strength through running, resistance training, battle specific physical training and loaded marches, culminating with a combat fitness test (10-11). In addition, the course contains technical, tactical and Regimental specific military skills.

Injured recruits reported to the medical centre located within the camp and were seen by a General Medical Practitioner for an assessment and diagnosis. Recruits who sustained MSKI and required physiotherapy intervention were then referred to the Physiotherapy department for further assessment and/or intervention (2). MSKI was calculated based on recruit referral to the physiotherapy department. Individuals who sustained MSKI but were managed successfully be either the Medical Officers and or Combat Medical Technicians were not included in this analysis. Musculoskeletal injuries were defined as pain, inflammation or functional disorder that involves the bones, joints, muscles, tendons, ligaments, and associated connective tissue injury (1-2,7). Blistering and cellulitis were not included (10,18).

Based on individual clinical judgment and in keeping with the clinical guidelines presented by the Directorate of Defence Rehabilitation and Occupational Medicine at ARTD, further investigation such as diagnostic ultra sound, X-ray and or MRI/MRA scans were used to confirm or reject initial clinical diagnoses and to direct management. Furthermore, MSKI was sub-classified as acute traumatic, insidious overuse, and recurrent (7-8,10).

Data analysis

Survival probability for the four training Regiments were calculated using a Kaplan-Meier analysis and the log rank test was used to examine overall differences of MSKI (23). The cumulative incidence

at a time point was simply one minus the survival probability (23). This model is appropriate and widely used in comparing two or more groups and both censored and events of interest data (2, 23). Exposure time was defined as the length of time recruits spend in training without MSK injury. Censored cases were represented at the point when recruits had no MSKI over the 26 week period (2). In recruits developing MSKI, proportion of survival was calculated to the point of diagnosis (2).

A Chi-square test was used to test the differences in injury type sub-classification (acute, overuse and recurrence) and training outcomes. Risk, relative risk and 95% confidence interval (CI) were also calculated between the Regiments (21). Statistical analysis was performed using SPSS 21.0 (SPSS Inc, Chicago, USA).

Results

The cumulative incidence of all injury sub-classifications for the four regiments were Parachute 86% (95% CI: 85.7-86.3), Guards 46% (95% CI: 45.6-46.5), Line 48% (95% CI: 47.8-48.2) and Gurkha 10% (95% CI: 9.1-10.9). The Kaplan-Meier curve (Figure 1) shows the proportion of recruits who were free from MSKI at each week of the 26 week training. The log rank analysis shows significant differences (X^2=792.5,$p< 0.001$) between the four regiments with the highest incidence in the Parachute Regiment (86%) and the lowest in the Gurkha Regiment (10%). The section of the graph where the line is steepest indicates the period when recruits are most at risk for developing an injury. Injuries were reported most frequently in the first nine weeks of training, with the highest rate of injury occurring in week two of training, after which incidence gradually declined until the end of phase 1 training at week 12. Thereafter, another injury peak emerged in phase 2, at week 17 (4.2%). Specifically, the CIC Parachute Regiment experienced a distinct injury peak between weeks 17-20 (Figure 1). The CIC Parachute, Line and the Guards Regiments had 8.6, 4.7 and 4.5 times the risk of sustaining a MSKI compared to the Gurkha Regiment (Table 2).

Sub-classifications of injury type with relative risk among Regiments is presented in Table 3. There was a significant difference in the injury types (X^2=688.01, $p< 0.01$) with a high incidence of overuse

injury recorded across all regiments. The Parachute Regiment had the highest recorded incidence of overuse injuries (54.7%) followed by Gurkha (43.5%); there were no differences between the Line and Guards Regiments (40.5%). Across, all Regiments, the overall injury distribution was; overuse (43%) followed by acute (32.8%) and then recurrence (24.2%). The relative risk of developing an overuse injury compared to a recurrent injury was 2.9 in Parachute, 2.5 in Gurkha, 1.6 in Guards and 1.5 for Line (Table 3). However, no significant differences were found between the incidences of recurrent and overuse injuries in the Gurkha Regiment. Notably, 18% of the recurrent injuries were also overuse in nature. Consequently, overuse injuries accounted for an overall total of 61.4% of all MSKI across all Regiments.

The training outcome (number of recruits passing out first time) was determined using the X^2 test. The results showed a significant difference ($p = 0.02$) between Regiments. Recruits successfully passing out from training at the first attempt were; 38%, 51%, 56% and 98% for the Parachute, Guards, Line and Gurkha Regiments, respectively.

Discussion

Incidence Rate

The overall Regimental specific incidence rates in this study ranged from 10 to 86%. The Parachute Regiment displayed both the highest incidence of injury and the lowest first time pass. The incidence of injury in the Line (48%) and Guards (46%) Regiments are comparable with the civilian running populations (25 to 65%) (5) but are considerably lower than professional dancers (67 to 95%) (24). Incidence of injury for both Line and Guards is also comparable to other military studies, with a range of 20% to 60% (2,3-4,16-17). Overall, the incidence of all injury types is lower in the Gurkha Regiment (10%) and highest in the Parachute Regiment (86%). The latter is comparable within the range of incidence reported for professional dancers (67 to 95%) (24) but higher than those reported for other military populations (8, 2-4,17-18). The risk of sustaining a MSKI was markedly higher for the Parachute, Line and Guards than the Gurkha Regiment. It is widely reported in the literature that MSKI,

especially overuse injuries often result from an abrupt increase in physical activity volume and intensity (1,8). This may be considered as a distinct training error (8). Differences in injury incidence between the Regiments may possibly be explained by a combination of the individual regimental selection processes, the content and delivery of the training programme and or the willingness of recruits to report injury (8,14,25). The Parachute Regiment had the most vigorous physical training of all regiments (12). Specifically, it involved the greatest amount of running, marching and milling, as well as two week specialist Parachute selection course (P- Company). The P-Company course was performed during the 17-20 week point within the CIC training programme. A combination of prolonged high load physical training, mental stress, working in unfamiliar or challenging environments, with external expectations of performance and associated sleep restriction may all contribute to impaired immune function (15-16). A compromised immune system together with insufficient recovery may contribute to the development of MSKI (1-2,13-16).

In contrast to all other Regiments, Gurkha recruits attend a language course, delivered in two and three week blocks every 7-8 weeks. These modules represent a break from both infantry training and directed physical training. During this time, physical training is self-directed and not monitored by the training teams. However, anecdotally, it is believed that recruits run 1-2 times per week for 30-40 mins mainly in the evening at their individual pace. There is no method to assess the quantity, volume, frequency, or quality of their involvement in other forms of training such as resistance and/or circuit training. This period, although not structured, presents opportunity for relative rest and recovery from both military tactical and physical training. This may help prevent over training (15), and thus contribute positively to musculoskeletal conditioning and health (14,26).

Cultural and socio-economic differences may influence the injury data recorded. The Gurkha Regiment has a physically arduous and intensely competitive selection. The socio-economic implication of successful enlistment to infantry training represents a huge opportunity for the individual recruit and their family. This serves as a significant motivation for the recruits to strive to avoid any action which

may compromise their chances of successfully completing training. In this way, psycho-social factors may heavily influence the decision of Gurkha recruits from seeking medical help for the management of their injuries (10,25). This may result in under reporting of injuries and explain, in part, some of the variations in incidence. Given the lack of previous research on regimental specific injury data, it is not possible to compare with other studies carried out on the recruit population at ITC. However, there is a strong probability that the injury differences observed between the four training regiments could be due to variations in training loads and/or the delivery of the programmes. This study therefore provides strong justification for ongoing injury data surveillance and the need for future work to address injury causation and develop effective prevention strategies.

Injury Type

Our findings demonstrated that overuse injuries are the most common injuries reported across all training Regiments at ITC. This pattern of overuse injuries is comparable to other studies (1-2,7-8,19). Overall, relative risk of developing an overuse injury is 1.8 times compared to a recurrent injury, and 1.3 times the risk of sustaining an acute injury. However, the recruits undergoing Parachute training had the highest chance (2.9 times) of sustaining an overuse injury followed by the Gurkha Regiment (2.5 times), clearly ahead of both Guards (1.6 times) and Line (1.5 times).

It is well recognized that overuse MSKI are multi-factoral in cause (1,9,11,14). Unfortunately, there is no definitive single strategy for their prevention (1-2, 10). However, excessive volume and intensity training load applied too soon too quickly are the frequently recognized as risk factors (1,8,15). Variations in Regimental specific training may contribute to the range in injury incidence. However, the impact of recurrent injury during recruit training has not been widely investigated. To the best of our knowledge, this is the first study to examine the sub-classification of injury rates across different regiments at ITC.

The reported MSKI incurred during recruit training required medical assessment, treatment and subsequent rehabilitation which can be both expensive and time-consuming (1-2,11). In addition, there

is the possibility of temporary but lengthy interruption to training with the associated possibility of medical discharge and the permanent end to a military career (2, 9,11).

Training outcome/attrition rate

This study reports a high attrition rate across Regiments with the exception of Gurkhas. The high injury incidence would suggest a possible mismatch between the capability of the recruits and the physical requirements imposed by the course (10). However, this study found that overall first time pass out rates were slightly higher (38%) than those previously reported (35%) for the Parachute Regiment (12). The data reported in the internal ITC report shows that approximately 65% of all Guards recruits completed training either at their first attempt or after being back trooped for repeat training. The recruits, who successfully completed Guards training, had lower injury rates and higher physical performance measures as compared to those who voluntarily removed themselves from training. This may suggest that being physically better conditioned has positive influence on both injury incidence and retention (9-11,14).

Some studies have suggested that attrition is related to the nature of the physical and psychological demands in training (10,13,15). Training errors, including unnecessarily excessive mileage, inadequate recovery, inappropriate running pace (8), adverse biomechanics and lifestyle (14,26) as well as mental stressors (13,15) are established risk factors for all training injuries. It may be possible to adjust the loading during the training programme, particularly in the first few weeks, in such a way that might have a favorable effect on the structure and function of the wider neuromusculoskeletal system which in turn may reduce the incidence of injury (10, 25).

The strengths of this study are the large sample size, prospective study design and that the cohort trained in a similar environment. The data provide valuable baseline evidence as to the scale of the problem and a framework for a systematic approach to planning and setting priorities for injury prevention (20-21). However, there are some limitations in this study. Our sample is taken from Regiments which are predominantly all male and homogeneous in term of participant characteristics

and their participation in the Combat Infantry training programme. The homogeneous nature of our cohort makes it difficult to generalize injures across a range of different populations. Furthermore, we did not monitor training load and thus we are unable to quantify the relationship between load exposure and injury of incidence. Further investigation is recommended in order to determine whether there is any correlation between BMI, height, weight, fitness level, training load and risk of injury.

Conclusions

This study demonstrates variability both in injury incidence and training outcome/success rates between four CIC Regiments. Musculoskeletal injuries present a significant threat to recruits striving to pass out through infantry training. The CIC Parachute Regiment had both the highest incidence of injury with the lowest pass rate in training. We, therefore, suggest that injury prevention strategies for the Parachute Regiment and overuse injury receive high priority. Reduction of both physical and mental load, especially in the early week of training, may contribute to cost effective prevention of MSKI.

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Abbreviations: CIC: Combat Infantry's Course, MSKI: Musculoskeletal injury

Authors' Contributions:

JS and IS conceived the study, participated in its design, collected and analysed data. JS, JD, SD RH and IS drafted the manuscript, interpreted data and critically revised the manuscript.

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Table 1: The summary of physical training activities during CIC training.

Activity	Description
Loaded march	Line, Guards and Gurkha- 8 miles loaded march in 2 hours. PARA- 10-20 miles loaded march 10 miles in 1 hour 50 min and 20 miles in P-Company over 4 hour 30 min.
Running	Running distances of 4 to 10 miles over specified routes
Obstacles /steeplechase	Running, jumping, scaling walls, vaulting and negotiating other obstacles
Circuit Training	Running, sit-ups, push-ups, weights
Swimming	Swimming, pool entry and exit, poolside sit ups/ push ups
Battle training	Wrestling, log lifts, fireman's carry training, shoulder rolls, Battle physical training
Military exercise/range/navigation	Field craft, firing, section attack/ map reading/navigation, drill, marching
Drill/marching	Foot drill and march

Table 2: Numbers of musculoskeletal injury (MSKI), relative risk (RR) and 95% confidence interval (CI) between Infantry Regiments during initial training.

Regiment	MSKI		Total	RR
	Yes	No		(95% CI)
Gurkha	46	412	458	1 (Reference)
Line	2079	2293	4372	4.7 (3.6 - 6.2)
Guards	476	568	1044	4.5 (3.4 - 6.0)
PARA	631	103	734	8.6 (6.5 -11.3)

Table 3: Injury Type, relative risk (RR) and 95% Confidence Interval (CI) between Infantry Regiments.

Regiment	Recurrent		Acute		Overuse	
	Number (%)	RR	Number (%)	RR (95% CI)	Number (%)	RR (95% CI)
Line (n = 4372)	530 (25.5)	Reference	704 (33.9)	1.32 (1.2 -1.5)	845 (40.6)	1.5 (1.4 - 1.8)
PARA (n = 734)	118 (18.7)	Reference	168 (26.6)	1.4 (1.2 - 1.8)	345 (54.7)	2.9 (2.4 3.5)
Guards (n = 1044)	121 (25.4)	Reference	162 (34.0)	1.3 (1.1- 1.7)	193 (40.5)	1.6 (1.2 -1.9)
Gurkha (n = 458)	8 (17.4)	Reference	18 (39.1)	2.3 (0.9 - 5.1)	20 (43.5)	2.5 (1.1 - 5.6)
Total (n = 6608)	777 (24.0)		1052 (32.5)		1403 (43.4)	
RR (95% CI)	Reference (1)		1.4 (1.2 -1.5)		1.8 (1.7 - 1.9)	

Figure 1.

Kaplan-Meier survival curve for the proportion of survival among four regiments survival curves for the Parachute (green), Line (blue), Guards (gray) and Gurkha (purple) Regiments.